



**Description of the advertisement calls
of nine species of
Fejervarya Bolkay, 1915 and
Minervarya Dubois, Ohler &
Biju, 2001 from China, India and Nepal**

Stéphane GROSJEAN & Alain DUBOIS

Reptiles et Amphibiens, UMR 7205 OSEB,
Département Systématique & Evolution, Muséum national d'Histoire naturelle,
25 rue Cuvier, 75005 Paris, France
<sgrosjea@mnhn.fr>, <adubois@mnhn.fr>

The advertisement calls of eight species of the genus *Fejervarya* and of *Minervarya sahyadris* (Dicroglossidae) are described in detail. This includes the advertisement calls of the holotypes of *F. pierrei*, *F. teraiensis* and *M. sahyadris*, as well as of a paratype of *F. nepalensis*. For each species, temporal and frequency parameters are provided, as well as an oscillogram and a spectrogram. The particular calls emitted before the advertisement call proper are discussed. The advertisement calls described herein are compared to previous call descriptions of the same species and some calls of unidentified *Fejervarya* species reported in literature are tentatively assigned to calls described herein. Calls of species which could occur in sympatry are compared to each other. The call of *M. sahyadris* is compared with the call of the recently described second species of the genus, *M. chilapata*.

INTRODUCTION

The genus *Fejervarya* is a taxonomically complex group of morphologically similar frogs comprising 32 currently recognized species distributed in Pakistan, India, Nepal, southern China, Indochina to the islands of the Sunda Shelf, and Japan and Papua New Guinea (FROST, 2010 [<http://research.amnh.org/vz/herpetology/amphibia/amphibia/>], 4 October, 2010).

Though the members of this genus inhabit open areas such as paddy fields and are usually quite common when present, their taxonomy is far from being fully resolved. Indeed this group of frogs is composed of morphologically very similar species, generally named *Fejervarya limnocharis*, which was so considered as a very largely distributed species. Even before molecular data (VEITH et al., 2001; KURABAYASHI et al., 2005; DJONG et al., 2007; KURAMOTO et al., 2007), advertisement calls turned out to be very useful in discriminating several new species of *Fejervarya* in the small country of Nepal, within the group that had been previously named *Rana limnocharis* (DUBOIS, 1975). The usefulness of advertisement



calls in discovery of new species or in the discrimination of sibling species is no longer debated (BOGERT & SENANAYAKE, 1966; LITTLEJOHN & OLDHAM, 1968; KURAMOTO, 1980; NARINS, 1983; MATSUI et al., 1986; SCHNEIDER & SINSCH, 1992; SCHNEIDER et al., 1993; NARINS et al., 1998). After the discovery of several species in Nepal (DUBOIS, 1975), ROY & ELEPFANDT (1993) recorded the call of three different *Fejervarya* species in a nearby region, northeastern India, thus confirming the existence of a species complex related to *Fejervarya limnocharis*.

Several field trips done by one of us (AD) from 1972 to 1992 permitted to record the calls of eight species of *Fejervarya* (*F. nepalensis*, *F. pierreii*, *F. rufescens*, *F. multistriata*, *F. syhadrensis*, *F. sp. 1*, *F. teraiensis* and *F. sp. 2*, among which the calls of the holotypes of *F. pierreii* and *F. teraiensis* and of one paratype of *F. nepalensis*), and of the holotype of *Minervarya sahyadris*. Four of these *Fejervarya* calls have been briefly described previously (DUBOIS, 1975) and the call of *F. rufescens* used in this work has been recently described (KURAMOTO & DUBOIS, 2009). The call of *F. rufescens* had been previously described by KADAVEVARU et al. (2000). Despite the importance of advertisement calls in species recognition and the abundance of the species of this genus in open and anthropized habitats, the calls of only a few additional *Fejervarya* species have been described until now: a species of Thailand referred to as *F. limnocharis* (HEYER, 1971), *F. cancrivora* from Kalimantan, Borneo (MATSUI, 1982), three unidentified *Fejervarya* species from northeastern India (ROY & ELEPFANDT, 1993), a species from southwestern India referred to as *F. limnocharis* (KANAMADI et al., 1995), a species from Bali, Indonesia tentatively referred to as *F. limnocharis* (MÁRQUEZ & EEKHOUT, 2006), *F. granosa*, *F. kudremukhensis* and *F. caperata* from southwestern India (KURAMOTO et al., 2007; the call of *F. kudremukhensis* has been described as *F. cf. keralensis* in KURAMOTO & JOSHY (2001) and the call referred to as *F. limnocharis* in the same paper could belong to *F. caperata*). The call of *M. sahyadris* has been described recently (KURAMOTO & JOSHY, 2001; KADAVEVARU et al., 2002; KURAMOTO et al., 2007; in the two first references as *Limnionectes syhadrensis*, KURAMOTO et al., 2007).

The goals of this paper are (1) to describe the calls of the specimens recorded during the fieldtrips of AD, (2) to provide the call characteristics of the holotypes of *F. pierreii*, *F. teraiensis* and *M. sahyadris*, these data being particularly useful in integrative taxonomy of Amphibians (e.g. VIETES et al., 2009), and (3) to compare them with the previously published call descriptions of *Fejervarya* species.

MATERIAL AND METHODS

The advertisement calls of nine species of Dicroglossidae of the genera *Fejervarya* and *Minervarya* were recorded in the field in India, Nepal and China from 1972 to 1992 by one of us (AD) (tab. 1, fig. 1–2).

Recordings were made using either an Uher Report 4000 or a Sony TCDM-5 tape recorders with two microphones LEM, and Scotch magnetic 215 and TDK SA-X90 tapes. Oscillograms and spectrograms were prepared with the Canary 1.2.4 software from the Cornell Laboratory of Ornithology (CHARIF et al., 1995). The sampling rate used to convert the signals to digital format was 22.254 Hz with a 16-bit precision. A filter bandwidth of

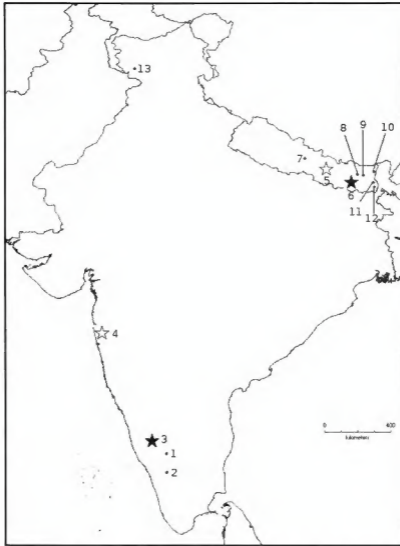


Fig. 1. – Recording localities and type localities of the *Fejervarya* and *Minervarya* species recorded in India and Nepal. Black stars represent type localities where advertisement calls have been recorded, white stars represent type localities. 1: Srirangapatna, recording site of *Fejervarya* sp. 1; 2: Udhagamandalam, recording site of *Fejervarya* sp. 2; 3: Gundia, type locality and recording site of *Fejervarya rufescens* and *Minervarya sahyadris*; 4: Poona district, Bombay Presidency, type locality of *Fejervarya syhadrensis*; 5: Godavari, type locality of *Fejervarya nepalensis*; 6: Birtamode, type locality of *Fejervarya pierrei* and *Fejervarya teraiensis* and recording site of *Fejervarya pierrei*, *F. syhadrensis* and *F. teraiensis*; 7: Kancagats, recording site of *Fejervarya syhadrensis*; 8: Lumkua, recording site of *Fejervarya syhadrensis*; 9: Sitda Pokhari, recording site of *Fejervarya nepalensis*; 10: Kunga, recording site of *Fejervarya nepalensis*; 11: Ilam, recording site of *Fejervarya teraiensis*; 12: Sanichare, recording site of *Fejervarya teraiensis*; 13: Patnitop, Jammu & Kashmir, north India, recording sites of several *F. syhadrensis* displaying the same temporal and frequency characteristics as the conspecific populations described here.

Table 1. – List of the species studied with information on the place and date of recording. Air T°: air temperature.

Species	Inventory number	Sound number	Country	Date (hours)	Locality	Coordinates	Altitude	Air T°
<i>Fejervarya</i> sp. 1	Lost (field number 7489.D)	8930	India	18.VII.1984 (21h00–01h20)	Srirangapatna	12.4136°N, 76.7042°E	740–800 m	No data
	Lost (field number 7559.D)	8931–8932	India	18.VII.1984 (21h00–01h20)	Srirangapatna	12.4136°N, 76.7042°E	740–800 m	No data
<i>Fejervarya rufescens</i>	(1)	8933	India	25.VII.1984 (20h30–00h15)	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
	(1)	8934	India	25.VII.1984 (20h30–00h15)	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
<i>Fejervarya</i> sp. 2	(2)	8935	India	13.VII.1984 (22h10–23h00)	Udhagamandalam	11.4°N, 76.7042°E	2200–2210 m	No data
<i>Minervarya sohyadris</i>	2000.3031 holotype	8936–8938	India	25.VII.1984	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
	2000.3033 paratype	8939	India	25.VII.1984	Gundia, Kempholey forest	13.0833°N, 76.1167°E	200–220 m	No data
<i>Fejervarya nepalensis</i>	1975.1628 paratype	8940	Nepal	9.V.1973 (19h10–22h45)	Kunga	About 27.5°N, 87.95°E	1580 m	21.0 °C
	1975.1676 paratype	8941	Nepal	12.V.1973	Sitda Pokhari	27.32°N, 87.38°E	1530–1550 m	No data
<i>Fejervarya pierrei</i>	1975.1680 holotype	8942	Nepal	21.V.1973 (20h15–01h15)	Birtamode	About 26.9167°N, 86.8°E	200 m	24.0 °C
	1975.1706 paratype	8943	Nepal	22.V.1973 (19h45–23h10)	Birtamode	About 26.9167°N, 86.8°E	200 m	No data
<i>Fejervarya syhadrensis</i>	1975.1679	8944	Nepal	22.V.1973 (19h45–23h10)	Birtamode	About 26.9167°N, 86.8°E	200 m	No data
	1995.2534	8945–8946	Nepal	6.VII.1973 (20h20–24h00)	Lumkua	27.37°N, 87.05°E	890 m	No data
<i>Fejervarya teraiensis</i>	1978.1751 (3)	8947	Nepal	8.IX.1972 (20h30)	Kanengats	About 28.2°N, 84.2°E	850 m	22.7 °C
	1975.1763 holotype	8948	Nepal	21.V.1973 (20h15–01h15)	Birtamode	About 26.9167°N, 86.8°E	200 m	24.0 °C
	1976.1147 paratype (4)	8949	Nepal	29.IV.1973	Ilam	26.9167°N, 87.9167°E	1180–1210 m	24–26 °C
		8950	Nepal	22.IV.1973 (20h00–24h00)	Sanichare	26.68°N, 87.98°E	250 m	21.5–32.5 °C
<i>Fejervarya multistriata</i>	Lost (field number T_2062)	8951	China	19.VIII.1992 (21h55)	Tunxi, Anhui Province	29.7114°N, 118.3125°E	125 m	27.3 °C

(1) 1984.2346, 1984.2348–2350 and 1984.2356; (2) 7426.D, 7429.D, 7454.D, 7499.D, V3 and V6; (3) a single calling male was caught but not necessarily the recorded one; (4) 1976.1128–1130, 1976.1132–1135.



Fig. 2. – Recording locality and type locality of *Fejervarya multistriata* from China. Black star represents the type locality (Lantau Island, Hong Kong), the black dot represents the site where the advertisement call has been recorded (Tunxi).

349.70 Hz and frame length of 512 points were used for both spectrogram and spectrum analyses.

A call is defined as a series of notes emitted consecutively and separated from another series of notes by a much longer interval than the interval separating two consecutive notes. In the case of *Fejervarya* species a call lasts from about ten seconds to several minutes, with the exception of *F. rufescens* for which a call is composed of only a long note. These long calling periods are named “calling bouts” hereafter. A note is an individual unit of sound composed of impulsions called pulses. A pulse is an energetic impulse. In the case of *Fejervarya* species, a note is composed of a series of pulses. The frequency bands are the different components visible on the spectrogram, the lowest being the fundamental, and the other the different harmonics. The band with the greatest emphasis is defined as the dominant frequency.

The following temporal parameters were scored from oscillograms: duration of the call (dc) and intercall duration (the silence interval between two consecutive calls, dic), duration of the notes (dn) and internote duration (the interval of silence between two consecutive notes, din), number of notes per call (nn) and note rate (the number of notes per second, nns), duration of pulses (dp), number of pulses per note (np), interpulse duration (dip) and pulse rate (number of pulses per second, nps). Frequency measurements were scored from the spectrum of a few notes within the signal and given as the mean of the frequency values of these notes for the same frequency band. The visible frequency bands are noted f1b to f3b from the fundamental frequency to the highest harmonic.

Most of the samples treated in this study are entire calls. However, the capacity of the software being reduced, we had to choose calls of short duration (lower to 5 seconds). Therefore the durations of calls (dn) are not typical values of the species.

All specimens are deposited in the herpetological collections of the Muséum national d'Histoire naturelle of Paris (MNHN); see tab. 1 for details. The calls described herein are deposited in the Fonoteca Zoológica of the Museo Nacional de Ciencias Naturales de Madrid (FZ collection numbers 8930–8951). A sample for each species is available in the web checklist of Frog Calls of the World, at <www.FonoZoo.com>.

All males of this genus have the same calling site. They call from the ground or from grasses on the ground, very close to the water edge but never in the water itself, only sometimes with the rear part of the body slightly in the water. Even if the males are within a flooded area, they call sitting on emergent mounds, or perched on emergent plants as in the case of *F. nepalensis* from Sitda Pokhari. So as all recorded males were outside water, only air temperature is given when available (tab. 1). All the *Fejervarya* species call in choruses and as such are heard from several dozen of meters by a human listener.

It is not possible to provide a collection number to each animal because some individuals could not be caught or were lost as a result of logistic problems. The calling male of *F. rufescens* was lost during storing before transportation. In these cases, the snout-vent length given was obtained by the mean of the snout-vent length of males caught in the population of the calling male. The collection numbers of individuals taken into consideration for calculation of the means are the following (tab. 1):

- (1) *Fejervarya rufescens*: 1984.2346, 1984.2348–2350 and 1984.2356.
- (2) *Fejervarya* sp. 2: 7426.D, 7429.D, 7454.D, 7499.D, V3 and V6.
- (3) A single calling male of *Fejervarya syhadrensis* has been caught but not necessarily the recorded one.
- (4) *Fejervarya teraiensis*: 1976.1128–1130, 1976.1132–1135.

OBSERVATIONS

INDIA

Fejervarya sp. 1

The three calls studied here are entire sequences. The call of *Fejervarya* sp. 1 (fig. 3a, tab. 2) is composed of a series of 9 to 16 multi-pulsed notes and lasts 3.24 s in average. The duration of notes averages 0.11 s and the intervals between them 0.15 s. The notes are emitted at a rate of 4.2 per second. Each note (fig. 3b) consists of about 20 pulses of very short duration (about 5 ms) and lacks pulse intervals. The pulses are emitted at a rate of 181 pulses per second on average. The duration of notes increases during the call. So, the number of pulses increases with the duration of notes (from 14 to 28 for the largest range). The notes have

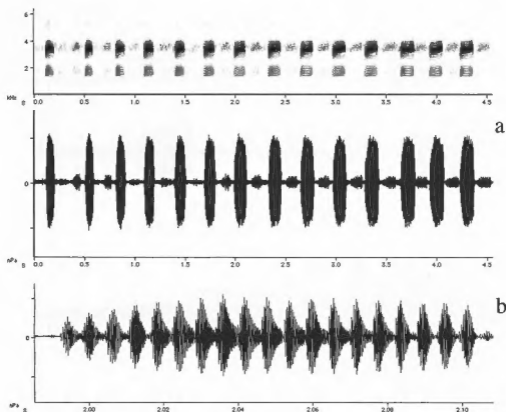


Fig. 3. – (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya* sp. 1 (field number D.7489) and (b) detailed oscillogram of the 7th note.

a very fast (abrupt) rise time and decrease just as fast. The amplitude of pulses increases abruptly at the beginning of the note and decreases slowly at the end.

The fundamental frequency lies at about 1724 Hz. The dominant frequency corresponds to the second frequency band (the first harmonic) and lies at about 3417.6 Hz. A slight upwards frequency modulation of the dominant frequency band is observed at the beginning of notes.

Fejervarya rufescens (Jerdon, 1854)

The advertisement call of *Fejervarya rufescens* (fig. 4a, tab. 2) is a long noisy note with increasing intensity. In this case, the call is synonym of note. The duration of the call is relatively short with a mean of 0.349 second, separated by a silence of 1.59 s in average and emitted at a rate of 0.74 notes per second. The calls are formed of about 60 pulses (fig. 4b). The amplitude of pulses increases greatly from the beginning of the note until the last pulses, the amplitude of which decreases abruptly. The pulses are emitted at a high rate, without silence between them.

Table 2. – Characteristics of the advertisement calls of several *Fejervarya* species and *Minervarya sahyadris* from India and of *Fejervarya multistriata* from China. MNHN: inventory number of MNHN; svl: snout-vent length of the recorded male in mm (when a mean is given, it refers to the mean of all caught males in the population of the recorded male; see *Material and methods* section); dc: duration of the call from first to last note; dic: duration of the interval between two consecutive calls; dn: duration of notes; din: duration of the interval between two consecutive notes; nn: number of notes per call; nns: number of notes per second; dp: duration of pulses; np: number of pulses per note; nps: number of pulses per second; f1b: frequency of the band *i*. Time measurements expressed in seconds; frequency in Hz. Values are given as: mean \pm standard deviation, minimum-maximum, (number of measurements).

Species	MNHN	svl	dc	dic	dn	din	nn	nns	dp	np	nps	f1b	f2b	f3b
<i>Fejervarya</i> sp. 1	7489.D	-	4.28	-	0.111 \pm 20.7 0.080–0.134 (14)	0.207 \pm 36.5 0.154–0.305 (13)	14	3.3	about 0.006	18.7 \pm 3.2 14–22 (14)	169.5 \pm 3.7 164.0–175.9 (14)	1807	3448	-
<i>Fejervarya</i> sp. 1	7559.D	-	2.72 1.86–3.58 (2)	-	0.110 \pm 19.6 0.073–0.143 (25)	0.116 \pm 48.4 0.083–0.297 (23)	12.5 9–16 (2)	4.7 4.5–4.8 (2)	about 0.005	20.7 \pm 4.0 14–28 (25)	188.7 \pm 8.1 169.8–201.5 (25)	1535–1802	3017–3788	-
<i>Fejervarya rufescens</i>		33.1 \pm 1.36 32.3–35.5 (5)	0.349 \pm 0.72 0.267–0.422 (4)	1.59 \pm 0.46 (2)	-	-	1 1–1 (4)	0.7 0.7–0.8 (2)	-	about 60	-	1117–1420	2410–3027	-
<i>Fejervarya</i> sp. 2		32.8 \pm 1.68 30.5–35.3 (6)	1.57	-	0.095 \pm 0.024 0.068–0.125 (4)	0.398 \pm 0.024 0.371–0.417 (3)	4	2.5	0.009	5.25 \pm 0.96 4–6 (4)	55.2	818.7	1068.5	-
<i>Minervarya sahyadris</i>	2000.3031	19.1	0.776 \pm 0.103 0.668–0.872 (3)	-	0.034 \pm 0.006 0.023–0.047 (24)	0.071 \pm 0.055 0.026–0.245 (21)	8 \pm 1 7–9 (3)	10.4 \pm 1.1 9.2–11.4 (3)	0.004– 0.007	6.63 \pm 1.41 5–10 (24)	202.5 \pm 30.1 152.4–256.2 (3)	3625–3700	-	-
<i>Minervarya sahyadris</i>	2000.3033	18.0	0.998	-	0.032 \pm 0.005 0.027–0.044 (10)	0.076 \pm 0.049 0.050–0.203 (9)	10	10.0	about 0.004	7.00 \pm 1.15 6–9 (10)	218.5	3694.4	-	-
<i>Fejervarya multistriata</i>	T.2062	37.3	0.381 0.367–0.394 (2)	1.53	0.080 \pm 0.011 0.070–0.094 (4)	0.210 0.191–0.229 (2)	2 2–2 (2)	5.3 5.1–5.5 (2)	0.010	7.25 \pm 0.5 7–8 (4)	91.1 \pm 7.9 83.9–99.6 (4)	1371	3017	4007

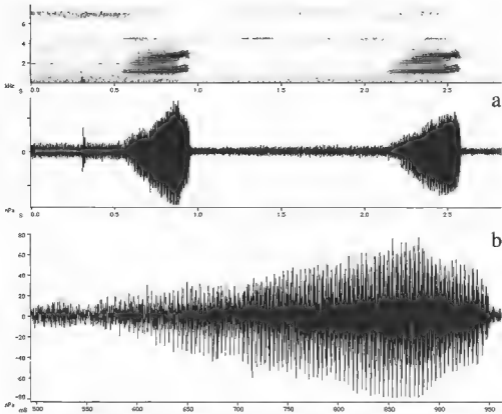


Fig. 4. (a) Spectrogram and oscillogram of two advertisement calls of *Fejervarya rufescens* and (b) detailed oscillogram of the 1st call

Two frequency bands are present, the fundamental lying at 1117–1420 Hz whereas the dominant lies at 2410–3027 Hz. The frequency of the note increases during its emission, which is especially visible in the dominant frequency. This change of frequency within the note is coupled with an intensity modulation to the note (increase in this case)

Fejervarya sp. 2

The call of *Fejervarya* sp. 2 (fig 5a, tab. 2) is composed of short multi-pulsed notes. The notes last 0.095 s in average, are separated by silences of 0.398 s in average and are emitted at a rate of 2.5 notes per second. The maximum amplitude of the note is reached in the middle of the note. The notes are composed of two or three groups of two pulses (fig. 5b). These groups are separated by durations comprised between 0.012 and 0.047 second. There are no silences inside the groups. Despite the variation of the duration of notes and of the number of pulse groups, the call appears homogenous to the listener.

Two frequency bands are present, the fundamental lying at about 820 Hz and the dominant at about 1070 Hz.

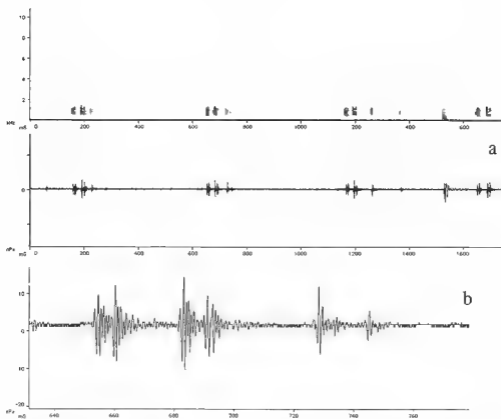


Fig. 5. (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya* sp. 2 and (b) detailed oscillogram of the 2nd note

The sample described here is only a short part of a calling bout. It does not represent an entire call.

Minervarya sahyadris Dubois, Ohler & Biju, 2001

The specimen recorded is the holotype of *Minervarya sahyadris*

The call of *M. sahyadris* (fig. 6a, tab. 2) lasts less than 1 second and is composed of a series of 7–10 multi-pulsed notes. The notes which last in average 0.033 s are emitted very quickly (about 10 notes per second) and are high-pitched. The duration of internote intervals is relatively short (0.073 s in average). The first note is always longer, with a greater amplitude, composed of more pulses, and separated from the second one (mean $d_{in} = 0.190$ s) by a longer interval than all the following notes between them. The second note, though of same amplitude and duration as the following ones, is frequently separated from the third one by a slightly longer silence than those between the following notes (mean $d_{in} = 0.096$ s). The mean duration of the internote intervals between the following notes is 0.048 s. Consequently, the

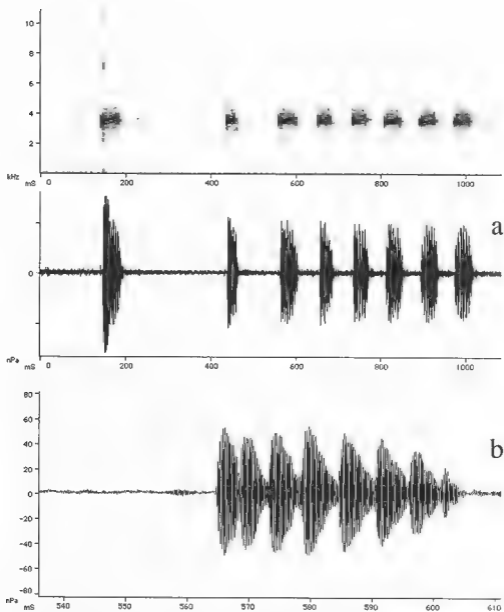


Fig 6 (a) Spectrogram and oscillogram of an advertisement call of the holotype of *Mimerarva sahyadris* (MNHN 2000.3031) and (b) detailed oscillogram of the 3rd note

Table 3 Characteristics of the advertisement calls of four species of *Fejervarya* from Nepal For legends, see Table 2 dip interpulse duration

Species	MNHN	svl	dc	dic	dn	D _{in}	nn	nns	dp	dip	np	nps	f1b	f2b	f3b
<i>Fejervarya nepalensis</i>	1975 1628	27.4	3.76	-	0.385 ± 0.013 0.370-0.406 (5)	0.460 ± 0.036 0.430-0.505 (4)	5	1.3	0.001	0.003	58.2 ± 2.8 46-63 (5)	151.0 ± 2.8 148.0-155.2 (5)	1711.3	2834.3	4303.6
<i>Fejervarya nepalensis</i>	1975 16 6	28.9	4.50	-	0.173 ± 0.005 0.164-0.181 (10)	0.306 ± 0.060 0.228-0.390 (9)	10	2.2	0.007	-	2.4 ± 0.5 21-22 (10)	124.0 ± 3.3 117.5-131.5 (10)	828.3	3631.3	-
<i>Fejervarya piurea</i>	1975 1680	29.5	2.96	-	0.249 ± 0.010 0.247-0.275 (9)	0.078 ± 0.005 0.072-0.085 (8)	9	3.0	0.004	0.001	19.7 ± 1.9 17-23 (9)	76.0	1880.6	4212.3	8581.3
<i>Fejervarya piurea</i>	1975 1706	30.0	3.53	-	0.257 ± 0.027 0.221-0.302 (10)	0.30 ± 0.064 0.072-0.274 (9)	10	2.8	0.003	0.001	18.6 ± 2.0 16-22 (10)	72.4	717.6	4114.3	-
<i>Fejervarya schubertii</i>	1975 1679	27.1	2.86	-	0.061 ± 0.007 0.054-0.081 (26)	0.051 ± 0.007 0.039-0.067 (25)	26	9.1	0.005	-	11.9 ± 1.4 11.15 (26)	194.7 ± 6.0 180.4-201.7 (26)	1548	3467.7	-
<i>Fejervarya schubertii</i>	1995 2534	29.5	2.94 2.91-2.97 (12)	-	0.054 ± 0.004 0.045-0.066 (54)	0.059 ± 0.041 0.05 ± 0.226 (52)	27 (2)	9.1 (2)	0.005	-	10.7 ± 0.8 9.13 (54)	99.7 ± 8.77 183.6-219.1 (28)	1638	3340.5	5346.5
<i>Fejervarya schubertii</i>	1978 1751	28.6	1.41	-	0.052 ± 0.004 0.046-0.058 (13)	0.061 ± 0.021 0.046-0.125 (12)	13	9.2	0.004	-	11.5 ± 0.5 11.12 (13)	219.7	1709.5	3600.5	5622.7
<i>Fejervarya tenenensis</i>	1975 1763	41.6	2.53	-	0.071 ± 0.005 0.066-0.079 (9)	0.232 ± 0.097 0.158-0.438 (8)	9	3.6	about 0.014	-	5.3 ± 0.5 5.6 (9)	74.8	1117	2439	3879.3
<i>Fejervarya tenenensis</i>	1976 1147	35.1	1.07 1.06-1.09 (12)	0.765	0.103 ± 0.021 0.64-0.119 (6)	0.372 ± 0.173 0.179-0.557 (4)	3	2.8	about 0.013	-	7.2 ± 1.3 4.8 (6)	69.4	1117	2454	3840
<i>Fejervarya tenenensis</i>	-	40.6 ± 4.12 31.9-44.0 (7)	1.28 0.927-1.63 (12)	0.37	0.081 ± 0.009 0.067-0.094 (8)	0.317 ± 0.071 0.189-0.374 (6)	4 3-5 (7)	3.7 3.1-3.7 (7)	about 0.014	-	5.6 ± 0.5 5.6 (8)	69.6	1038	2.16	27.6.6

emission rate of the notes increases during the call. The notes are composed of 5 to 10 very densely arranged pulses lasting from 4 to 7 ms and without silence between them, and emitted at a rate of 200 pulses per second (fig. 6b). The largest pulse is usually the first or the second of each note, then their amplitude decreases. So the maximum amplitude of the note is reached very quickly after what the amplitude of the note decreases more slowly. The structure of the pulses resembles that of the note.

Only the fundamental frequency, which is also the dominant frequency, is visible. It lies at about 3650 Hz.

NEPAL

Fejervarya nepalensis (Dubois, 1975)

Contrary to the other species, *F. nepalensis* (fig. 7) is a forest species. During day time, it is often found on the forest floor. It is also found near ponds at the edge of forests.

The advertisement call of *Fejervarya nepalensis* is a sequence of long multi-pulsed notes. It is remarkable, however that this is the only characteristic shared by the calls of the two specimens recorded from two different localities. The recording person noticed differences between the two frogs in his fieldnotes. As these two calls differ in all respects, they are described independently.

The call of *F. nepalensis* from Kunga (paratype), which is an entire call sequence, is composed of long notes (0.385 s in average) separated by long intervals (0.460 s in average)



Fig. 7. A female of *Fejervarya nepalensis* from Bibare Bazar, Nepal, the 13th July 1973

and emitted at a slow rate of 1.3 note/s (fig. 8a, tab. 3). The duration of the notes and of the intervals between notes are the largest among the species described herein whereas the note rate is the slowest of all species. The notes are composed of a large number of pulses (56–63) of 3 ms of duration with a group of greatest amplitude at the beginning of each note (fig. 8b). Three frequency bands are visible, the fundamental frequency lying at about 1710 Hz, the dominant at about 2830 Hz and the third band of energy at about 4300 Hz. The dominant frequency shows an upwards frequency modulation within each note.

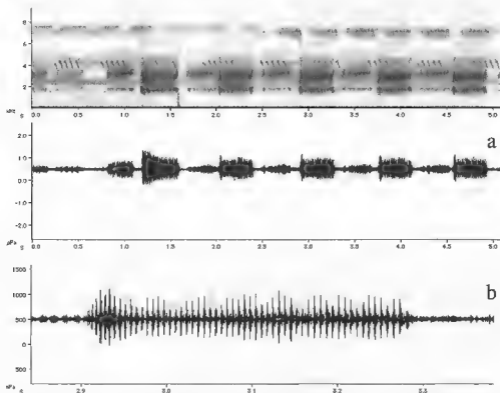


Fig. 8. (a) Spectrogram and oscillogram of an advertisement call of one paratype of *Fejervarya nepalensis* (MNHN 1975 1628) from Kunga and (b) detailed oscillogram of the 3rd note. The notes of a second calling male are visible between the notes of the described call.

The call of *F. nepalensis* from Sitda Pokhari (paratype) is composed of shorter notes of 0.173 s in average separated by intervals of 0.300 s in average and emitted at a rate of 2.2 notes/s (fig. 9a, tab. 3). This is only a part of call which can last until two minutes. The notes are composed of 21–22 pulses of 7 ms of duration arranged in three groups per note, the pulses of each group increasing then decreasing in amplitude (fig. 9b). Two frequency bands are visible, the first one at about 1830 Hz and the second at about 3630 Hz. The dominant frequency is the fundamental.

In summary, the calls of these two specimens differ in the duration of the notes, the duration of the intervals between them, the number of pulses per note, and the pulse and note

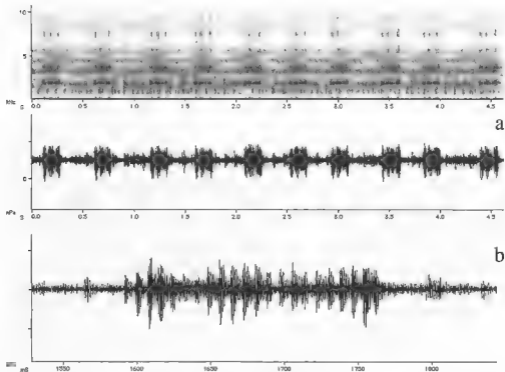


Fig 9. – (a) Spectrogram and oscillogram of an advertisement call of one paratype of *Fejervarya nepalensis* (MNHN 1975 1676) from Sitda Pokhari and (b) detailed oscillogram of the 4th note.

rate. The frequency bands are higher in individual from Kunga and the dominant frequency is not represented by the same harmonic in the two individuals. These two calls probably belong to two different species.

Fejervarya pierrei (Dubois, 1975) (fig. 10)

One of the calls described herein was emitted by the holotype (MNHN 1975.1628, fig. 11).

The call of *Fejervarya pierrei* (fig. 12a, tab. 3) is a series of long multi-pulsed notes lasting 0.258 s in average. The durations of internote intervals are short, 0.092 s in average, in comparison to the calls of the other *Fejervarya* species. However, due to the relatively important duration of notes, the note rate (2.9 notes per second) is not affected. These notes are composed of five or six groups of three to five large pulses separated by seven or eight small pulses (fig. 12b) giving the call a trill-like sound. The first or the second group of pulses has the greatest amplitude which decreases slightly in the subsequent pulse groups.

Two or three frequency bands are present, the fundamental lying at about 1800 Hz, the second and dominant frequency is about 4200 Hz and the third one, when present, at about 8600 Hz.

This call sounds like a cricket song.

Fejervarya syhadrensis (Annandale, 1919)

The calls analysed herein (from Birtamode, Lumkua and Kaneagats, Nepal) are whole sequences but chosen among the shortest for the convenience of the software limitations (the maximum length capacity of the software is 14 s). The call of *Fejervarya syhadrensis* (fig. 13 and 14a, tab. 3) is a fast series of short multi-pulsed notes (0.055 s on average). The durations of internote intervals are very reduced ($din = 0.057$ s, $n = 89$). This is the highest call rate among calls studied here (9.17 notes per second on average) due to both short note and internote intervals. Each note is composed of 9–15 pulses (about 0.005 s) without interpulse

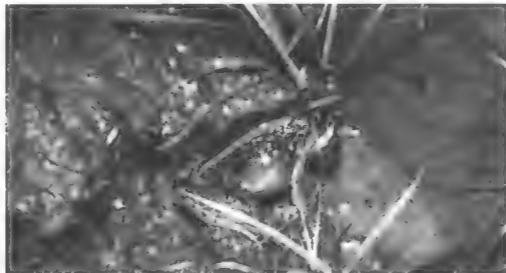


Fig. 10. A calling male of *Fejervarya pierrei* from Belbart, Nepal, the 23rd May 1973



Fig. 11. The holotype of *Fejervarya pierrei* (MNHN 1975.1680) from Birtamode, the 21st May 1973

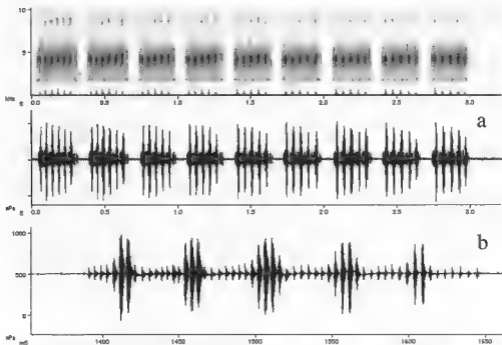


Fig. 12. – (a) Spectrogram and oscillogram of an advertisement call of the holotype of *Fejervarya pierrei* (MNHN 1975.1680) and (b) detailed oscillogram of the 5th note.

interval (fig 14b). The amplitude of pulses increases slightly at the beginning of call and decreases in the same way at the end. The last pulse is always shorter than the previous ones.

These calls typically have one note then two groups of two notes before a rapid and continuous emission of notes. Although the duration and the number of pulses of any note in the call is noticeably the same, the silence duration between each of these groups is three to four times bigger (0.171 ± 0.037 , $n = 6$) than the silences within both the groups of two notes and the following succession of notes (0.048 ± 0.007 , $n = 83$).

The fundamental frequency is at about 1634 Hz and the dominant frequency peak (the first harmonic) lies at about 3440 Hz. The spectrogram is characterized by a wide range with up to six harmonic bands.

Fejervarya teraiensis (Dubois, 1984) (fig. 15)

The call of the specimen MNHN 1975.1763, which is the holotype of *F. teraiensis* (fig. 16), described here, is only a small sample of a calling bout lasting about 1.5 minute. The calls of the two other specimens analysed herein are whole calls.

The call of *Fejervarya teraiensis* (fig. 17a, tab. 3) is a continuous series of short multipulsed notes. The duration of notes averages 0.085 s and the intervals between them, 0.31 s. The duration of the intervals between the notes is highly variable, even within a call (range 0.158–0.557 s, SD = 0.118, $n = 18$). So the notes are emitted at an irregular rate. The note rate

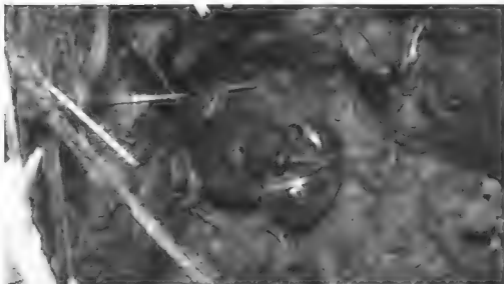


Fig. 13 A calling male of *Fejervarya syhadrensis* from Burimorang, Nepal, the 24th July 1973.

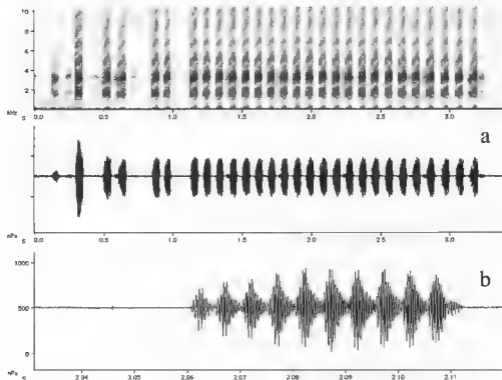


Fig. 14. - (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya syhadrensis* (MNHN 1995.2534) from Lumkua and (b) detailed oscillogram of the 16th note.

is about 3.2 notes per second. Each note consists of 5-8 large pulses (fig. 17b) without interpulse intervals ($dp = 0.014$ s). The amplitude of the note increases quickly (the second pulse is the largest) and decreases more slowly.

The dominant frequency is about 2450 Hz for the two first calls and 1040 Hz for the third. We can notice here a change in the dominant frequency: the dominant frequency is equal to $f2b$ for the two first calls and $f1b$ for the last one.

The spectrogram shows a wide frequency range with up to seven harmonic bands.

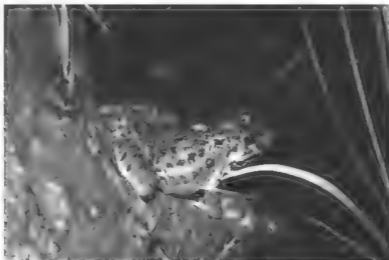


Fig. 15 A male paratype of *Fejervarya teraiensis* (MNHN 1975.1764) from Burmorang, Nepal, the 27th July 1973.



Fig. 16 The holotype of *Fejervarya teraiensis* (MNHN 1975.1763) from Birtamode, the 21st May 1973

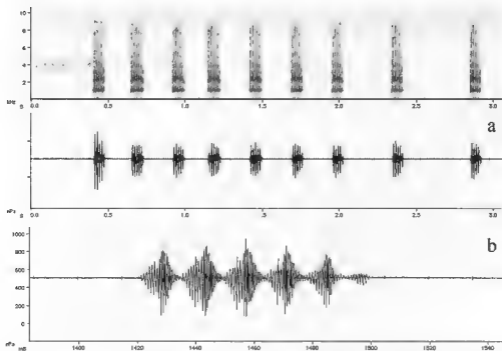


Fig 17 - (a) Spectrogram and oscillogram of an advertisement call of the holotype of *Fejervarya teraiensis* (MNHN 1975 1763) and (b) detailed oscillogram of the 5th note.

Table 4 - Comparison of the frequency ranges of each frequency band among the four species of *Fejervarya* recorded from Nepal and the three species recorded from southwestern India.

	Species recorded from Nepal				Species recorded from southwestern India		
	<i>F. teraiensis</i>	<i>F. sylvadensis</i>	<i>F. nepalensis</i>	<i>F. pterret</i>	<i>Fejervarya</i> sp. 2	<i>F. rufescens</i>	<i>Fejervarya</i> sp. 1
1 st band	1.0-1.1	1.5-1.7	1.7-1.8	1.7-1.8	0.8	1.1-1.4	1.5-1.8
2 nd band	2.1-2.4	3.2-3.6	2.8-3.6	4.1-4.2	1.0	2.4-3.0	3.0-3.8
3 rd band	2.7-3.9	5.1-5.6	4.3	5.6	-	-	-

CHINA

Fejervarya multistriata (Hallowell, 1861)

The call of *Fejervarya multistriata* (fig. 18a, tab. 2) is a short call (0.380 s) composed of groups of two multi-pulsed notes. These are only a few notes emitted before a longer call. These two groups of two notes are separated by an interval of 1.53 s. The duration of notes averages 0.08 s and the intervals between them, 0.21 s. The note repetition rate is relatively high (5.26 notes per second). Each note consists of seven or eight large pulses (10-12 ms) which have a decreasing amplitude throughout the note (fig. 18b). There is no silence interval between two consecutive pulses.

The dominant frequency is 1371 Hz. This is the only case where the dominant frequency is equal to the fundamental among the *Fejervarya* species studied here (except for *F. nepalensis*

from Sitda Pokhari). The frequency of the first pulse of each note is higher than the second resulting in frequency modulation.

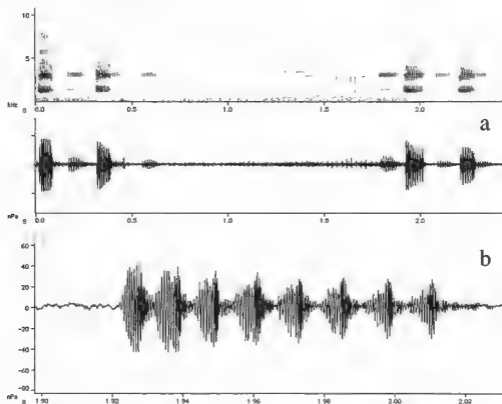


Fig. 18. (a) Spectrogram and oscillogram of an advertisement call of *Fejervarya multistriata* (T.2062) and (b) detailed oscillogram of the 1st note of the second call. The notes of a second calling male are visible between the notes of the described call.

DISCUSSION

The calls described herein are all, with the exception of *F. rufescens*, a long and regular succession of trilled notes. These calls can last more than one minute. The same structure has been reported for the calls of other species in northeastern and southwestern India (ROY & ELEPFANDT, 1993; KANAMADI et al., 1995; KURAMOTO et al., 2007).

The calls of *Fejervarya* species are often introduced by a few notes, often grouped by two. These notes are present before each advertisement call and in all calling males. These small calls sound like timid attempts of advertisement calls and are emitted until the group of calling males "feels at ease". Then, as soon as a male is "sufficiently reassured", it begins emitting the typical advertisement call, immediately followed by all the other males in its vicinity. If the frogs are "inhibited", these notes can be emitted for a long period (GROSJEAN & DUBOIS, pers. obs.) These notes emitted alone or in pairs with a longer internote duration

before and after the typical advertisement call were reported by DUBOIS (1975), who reported larger internote durations but larger note duration too unlike our results and interpreted these notes as territorial call. In the same paper, DUBOIS (1975) illustrated a territorial call of *F. teraiensis* (under the name *F. "limnocharis"*) which was much longer and structurally different from the notes of the advertisement call of this species. Furthermore, KANAMADI et al. (1995) observed the territorial behaviour of a *Fejervarya* species and described the territorial call whose notes have a different structure from the notes of the advertisement call. The few tentative notes at the beginning of the calls reported here have, on the contrary, exactly the same structure and the same duration as the following notes of the advertisement call. For these reasons we do not consider these notes as the territorial call.

The advertisement calls of *F. nepalensis*, *F. pierrei*, *F. syhadrensis* and *F. teraiensis* were briefly described elsewhere (DUBOIS, 1975, 1976).

The call of the specimen of *F. rufescens* studied here was described by KURAMOTO & DUBOIS (2009). The measurements of the call parameters reported by these authors and those described here are of course very similar except for the number of pulses which is reported to be 25 in average by KURAMOTO & DUBOIS (2009) and about 60 here (reflecting perhaps differences in detectability of the pulses). The advertisement call of this species has also been described previously from the Western Ghats (KADADEVARU et al., 2000). In this population the number of pulses was 49 in average. The waveform of the call of *F. rufescens* shown by these authors was very similar to that of the present study. However, the temporal values of our sample are bigger than those of *F. rufescens* from the Western Ghats. For instance the notes last 349 ms and contain 60 pulses in average in our samples vs 242 ms and 49 pulses, and the interval between each note lasts 1.6 s in our samples vs 0.556 s. KADADEVARU et al. (2000) reported five frequency bands whereas only two are visible in our specimens. The dominant frequency matches in the two samples 2400–3000 Hz in this study and 2500–3520 Hz reported by KADADEVARU et al. (2000). These differences could be due to temperature differences (unfortunately, no data are available for our recording), geographic variation or different hormonal state.

ROY & ELEPFANDT (1993) described the call of three unidentified species of *Fejervarya* from northeastern India. All the values of the temporal parameters (note duration, interval duration between notes and number of pulses) of the species referred to as *F. limnocharis* are higher than those of *F. nepalensis* from Kunga, the species from Nepal and northern India which exhibits the greatest temporal value. On the contrary, the dominant frequency is lower in "*F. limnocharis*" than in *F. nepalensis*. However, the general waveform of the notes of the two species resembles greatly. The species named sp. 1 in the same paper fits the call parameters of our *F. teraiensis*, a species which also occur in this region whereas the call parameters of the species named sp. 2 have no equivalent in our sample.

The distribution of *F. syhadrensis*, if actually this taxon is not a species complex, is large, spreading from eastern Pakistan to Bangladesh, northern India and Nepal and most probably to northeastern India. One of us (AD) identified and recorded a species close to *F. syhadrensis* reported here as *F. sp. 1*. However, except for the frequency parameters and the high pulse rate, the two calls share no similarity and sound differently. KANAMADI et al. (1995) described the advertisement call of a seemingly undescribed *Fejervarya* species. The call parameters (both temporal and frequency) reported by these authors perfectly fit the measurements of our *F. sp. 1* as does the structure of the note. These two populations are likely conspecific. On the

other hand, AD recorded also the calls of several *F. syhadrensis* from a distant population, at Patnitop, Jammu & Kashmir, northern India (about 1000 km distance; fig. 1). The calls of these specimens (data not shown) are identical to those described here, confirming the conspecificity of the two populations as well as the wide range of this species.

Among the eight *Fejervarya* species whose calls are described herein, three have been recorded in southwestern India (*F. sp. 1*, *F. rufescens* and *F. sp. 2*), four in Nepal (*F. nepalensis*, *F. pierrei*, *F. syhadrensis* and *F. teraiensis*) and one in China. Although the four Nepalese species inhabit different zoogeographic areas, they can occur in syntopy, particularly *F. syhadrensis* which can be found together with any of the three other species (DUBOIS, 1975, fig. 1). Thus, their advertisement call could play an important role as a premating isolating mechanism. The fundamental frequencies of three out of the four species overlap (tab. 4). Only the frequency bands of *F. teraiensis* are clearly outside the range of the three other species. *Fejervarya nepalensis* and *F. pierrei* have the same range of values for the fundamental frequency, but the dominant frequency plays probably the most important role. However, ROY & ELEPHANT (1993) suggested that a marked different dominant frequency between individuals might be useful for interindividual recognition. *Fejervarya syhadrensis* and *F. nepalensis* from Sitda Pokhari present the same dominant frequency but the calls differ clearly by the length of notes, the longest notes of *F. syhadrensis* remaining always shorter than the shortest notes of *F. nepalensis*. *Fejervarya syhadrensis* which can be found in syntopy with the three other species possesses the most divergent call. It has the shortest note durations, the shortest intervals between notes and the fastest call (which is expressed by more notes, high note rate and high pulse rate).

Fejervarya rufescens, *F. sp. 1* and *F. sp. 2* were all described from southwestern India (Karnataka and Tamil Nadu States). So they could potentially be syntopic. Here again, the advertisement call could be an important premating isolating mechanism. The values of the first two frequency bands do not overlap (tab. 4). Furthermore, *F. rufescens* has a very different call relative to the two other southwestern India species. Its notes are the longest as well as the intervals between them (which last more than one second). Due to the length of the notes, the note rate is particularly slow and the number of pulses high. The call of *F. sp. 2* is remarkable by its notes containing a low number of pulses.

The advertisement call of *Minervarya sahyadris* described herein is of importance as it is the call of the holotype. The type locality is near the village of Gundia, Kempholey forest, Hassan District, Karnataka, India (13 0833°N, 76.1167°E; altitude about 200 m). The advertisement call of *M. sahyadris* has already been reported from southwestern India: Mangalore and the Western Ghats (KURAMOTO & JOSHY, 2001; KADADVARU et al., 2002; KURAMOTO et al., 2007; in the two first references as *Lumnonectes syhadrensis* according to KURAMOTO et al., 2007). The three descriptions from the literature differ substantially between them, and the calls from the Western Ghats (KADADVARU et al., 2002) are most similar to the calls of the holotype. One of the most striking features of this call is the first note which is longer than the following ones (including more pulses) and separated from the second one by a longer interval than all the following note intervals of the call. This first longer note has also been reported by KADADVARU et al. (2002) but the first small pulse of the first note mentioned by these authors has not been observed in our calls. The three previously described calls and the calls described here share a mean dominant frequency of 3.6–3.8 kHz, a short call duration (0.668–1.21 s) and a number of notes per call ranging from 7 to 28.

The calls reported by KURAMOTO & JOSHY (2001) differ in structure from the other calls assigned to this species (KADADIVARU et al., 2002; KURAMOTO et al., 2007; this paper) with respect to the notes which increase in length during the emission of the call and which tend to be divided in pulse groups, ultimately reaching a duration of 300 ms which is about ten times the duration reported here and in KADADIVARU et al. (2002). The numerous and fine spectral bands are not found in the calls described in the other papers. The three frequency bands observed by KADADIVARU et al. (2002) were not found here, nor in KURAMOTO et al. (2007). Although the description of KURAMOTO et al. (2007) was very short, the structure of the call and the few parameters given fit well with the call of the holotype (although the notes are emitted at a faster rate in the call of KURAMOTO et al. (2007), i.e. 15.7 notes/s vs. 9.11 notes/s in the call of the holotype).

A second species of *Minervarya* has recently been described from West Bengal as *M. chilapata* (OHLER et al., 2009) and a short part of its advertisement call described. The structure of the call of this species is basically the same as that of *M. sahyadris*, consisting of a rapid succession of pulsed notes. Three frequency bands are found in *M. chilapata* vs. only one in *M. sahyadris*, lying at about 3.5, 7.0 and 10.5 kHz. Nevertheless the duration of the calls is greater (from 0.9 to 1.9 s) in *M. chilapata* and their calls include more notes (11–27), the duration of the notes is longer (70 ms in average), the notes are emitted at a quicker rate (13.6 notes/s) and there is no interval between two consecutive notes. Furthermore, the first longer note with a greater interval relative to the following characteristic of *M. sahyadris* was not found in *M. chilapata*.

The genus *Fejervarya* is a conservative genus composed of morphologically similar species. The taxonomy of this group is at present not fully resolved and new species will probably be described with increasing population samplings and data set collections (especially of molecular and acoustic data). In this paper, we described the advertisement call of the holotype of *F. pierrei*, *F. teraiensis* and *M. sahyadris*, of paratypes of *F. nepalensis*, and of topotypes of *F. rufescens*. These data should be very useful in species allocation (and taxonomy in general) of newly collected (and recorded) specimens. On the other hand, the advertisement calls attributed to *F. syhadrensis* and *F. multistriata* must be taken with caution as the recorded specimens were caught quite far from their respective type localities. In particular a recent study based on molecular data (KOTAKI et al., 2010) showed that at least some Chinese populations of *Fejervarya* belong actually to *Fejervarya limnocharis*. Further research is needed to confirm their specific allocation.

LITERATURE CITED

- BOGERT, C. M. & SINANAYAKI, R., 1966. A new species of toad (*Bufo*) indigenous to southern Ceylon. *Amer. Mus. Novit.*, **2269**: 1–18.
- CHARB. R. A., MITCHELL, S. & CLARCK, C. W., 1995. *Canary 1.2 User's Manual*. Ithaca, New York, Cornell Laboratory of Ornithology: i-viii + 1-251.
- DRING, T. H., ISLAM, M. M., NISHIOKA, M., MATSUI, M., OTA, H., KURAMOTO, M., KHAN, M. M. R., ALAM, M. S., ANSHEM, D. S., KHONSUE, W. & SUMIDA, M., 2007. Genetic relationships and reproductive-isolation mechanisms among the *Fejervarya limnocharis* complex from Indonesia (Java) and other Asian countries. *Zool. Sci.*, **24**: 360–375.
- DUBOIS, A., 1975. — Un nouveau complexe d'espèces jumelles distinguées par le chant: les grenouilles du Népal voisines de *Rana limnocharis* Boie (Amphibiens, Anoures). *C. r. Acad. Sci. Paris*, (D), **281**: 1717–1720.

- 1976 Chants et écologie chez les Amphibiens du Nepal *Coll int C N R S*, **268** 109–118.
- HEYER, W. R., 1971. – Mating calls of some frogs from Thailand *Fieldiana Zool.*, **58** (6): 61–82.
- KADADYARU, G. G., KANAMADI, R. D. & SCHNEIDER, H., 2000. – Advertisement call of two Indian ranids, *Indirana beddomii* and *Tomopterna rufescens*. *Amphibia-Reptilia*, **21**, 242–246.
- 2002 Advertisement call, courtship and mating behaviour of the frog, *Limnodynastes sylvadrensis* from Western Ghats, India. *Curr. Sci.*, **82**: 503–505.
- KANAMADI, R. D., HIREMATCH, C. R. & SCHNEIDER, H., 1995. Vocalization and territoriality of the Indian frog *Rana imnochoris*. *Proc. Ind. natn. Sci. Acad.*, **B61** (1): 9–14.
- KOTAKI, M., KURABAYASHI, A., MATSUI, M., KURAMOTO, M., DJONG, T. H. & SUMIDA, M., 2010. Molecular phylogeny of the diversified frogs of genus *Fejervarya* (Anura: Dicroglossidae). *Zool. Sci.*, **27**: 386–395.
- KURABAYASHI, A., KURAMOTO, M., JOSHY, H. & SUMIDA, M., 2005. Molecular phylogeny of the ranid frogs from Southwest India based on the mitochondrial ribosomal RNA gene sequences. *Zool. Sci.*, **22** (5): 525–534.
- KURAMOTO, M., 1980. Mating calls of treefrogs (genus *Hyla*) in the Far East, with description of a new species from Korea. *Copeia*, **1980**: 100–108.
- KURAMOTO, M. & DUBOIS, A., 2009. Bioacoustic studies on three frog species from the Western Ghats, South India. *Curr. Herp.*, **28**: 65–70.
- KURAMOTO, M. & JOSHY, S. H., 2001. Advertisement call structures of frogs from Southwestern India, with some ecological and taxonomic notes. *Curr. Herp.*, **20**: 85–95.
- KURAMOTO, M., JOSHY, S. H., KURABAYASHI, A. & SUMIDA, M., 2007. The genus *Fejervarya* (Anura: Ranidae) in central Western Ghats, India, with descriptions of four new cryptic species. *Curr. Herp.*, **26** (2): 81–105.
- LITTLEJOHN, M. J. & OLDHAM, R. S., 1968. – *Rana pipiens* complex: mating call structure and taxonomy. *Science*, **162**: 1003–1005.
- MÁRQUEZ, R. & ELKHOUT, X. R., 2006. – Advertisement calls of six species of anurans from Bali, Republic of Indonesia. *J. nat. Hist.*, **40**: 571–588.
- MATSUI, M., 1982. Call characteristics of several anuran species from east Kalimantan. *Contr. Biol. Lab. Kyoto Univ.*, **26** (2): 131–139.
- MATSUI, M., SETO, T. & UTSUNOMIYA, T., 1986. Acoustic and karyotypic evidence for specific separation of *Polypedates megalcephalus* from *P. leucomystax*. *J. Herp.*, **20** (4): 483–489.
- NARINS, P. M., 1983. – Divergence of acoustic communication systems of two sibling species of eleutherodactylid frogs. *Copeia*, **1983** (4): 1089–1090.
- NARINS, P. M., FENG, A. S., YONG, H.-S. & CHRISTENSEN-DALSGAARD, J., 1998. Morphological, behavioral, and genetic divergence of sympatric morphotypes of the treefrog *Polypedates leucomystax* in Peninsular Malaysia. *Herpetologica*, **54** (2): 129–142.
- OHLLER, A., DEUTZ, K., GROSJEAN, S., PALL, S., AYYASWAMY, A. K., AHMED, M. F. & DUTTA, S. K., 2009. Small-sized dicroglossids from India, with the description of a new species from West Bengal, India. *Zootaxa*, **2209**: 43–56.
- ROY, D. & ELFPFANDT, A., 1993. Bioacoustic analysis of frog calls from northeast India. *J. Biomet.*, **18** (3): 381–393.
- SCHNEIDER, H. & SINSCH, U., 1992. Mating call variation in lake frogs referred to as *Rana ridibunda* Pallas, 1771. Taxonomic implications. *Z. Zool. Syst. Evolut. Forsch.*, **30**: 297–310.
- SCHNEIDER, H., SINSCH, U. & SOFIANIDOU, T. S., 1993. The water frogs of Greece: Bioacoustic evidence for a new species. *Z. Zool. Syst. Evolut. Forsch.*, **31**: 47–63.
- VLIETH, M., KOSUCH, J., OHLLER, A. & DUBOIS, A., 2001. Systematics of *Fejervarya imnochoris* (Gravenhorst, 1829) (Amphibia, Anura, Ranidae) and related species. 2. Morphological and molecular variation in frogs from the Greater Sunda Islands (Sumatra, Java, Borneo) with the definition of two species. *Ah. tes*, **19**: 5–28.
- VHITUS, D. R., WOLLNBERG, K. C., ANDRILONI, F., KÖHLER, J., GLAW, F. & VINCELS, M., 2009. Vast underestimation of Madagascar's biodiversity evidenced by an integrative amphibian inventory. *Proc. natn. Acad. Sci. U.S.A.*, **106**: 8267–8272.

Corresponding editor: Rafael MÁRQUEZ.